Two Region Metal - Solution Sphere

In 1963, a report was published by Messrs. W. A. Reardon and C. F. Czerniejewski which dealt with minimum critical mass calculations for a fully water-reflected, idealized (spherical) plutonium dissolver system[1]. The report provided data on minimum critical masses, critical volumes, etc., for an idealized two-region (plus reflection) system representing plutonium-239 metal dissolving into solution. With the improved computer code calculation techniques available, a reanalysis was made in 1975[2]. The calculations were performed under the same general conditions as in the original document, the primary difference being the use of the DTF-IV transport theory code with GAMTEC II code cross sections in place of the original codes. In addition, the diffusion theory code HFN was used for the homogeneous system. Plutonium-water mixtures were used instead of plutonium oxide-water mixtures in the earlier work.

The system consisted of a plutonium metal core at a density of 19.6 grams/cc surrounded by a ^{239}Pu-H_2O mixture and fully reflected by water. The metal mass was held constant while the plutonium concentration in the mixture was varied. One of the relationships developed was the family of curves shown in Figure IV.A.5-2.

A line defining the envelope could then be drawn as shown, along the various curves, which defined the critical mass-volume relationship. The "always safe" terminology resulted from the fact that any mass-volume combination to the left of the envelope results in a subcritical system for a given total plutonium mass no matter how the plutonium is divided between the metal and metal-water mixture. (One should be aware, however, that these calculations are for a k-effective of 1.0. There is no allowance for possible bias).

(1) W. A. Reardon and C. F. Czerniejewski, "Idealized Plutonium Dissolvers and the 'Always Safe' Conditions," HW-SA-2999, General Electric Company, July 1963.

(2) C. O. Brown and R. D. Carter, "Reanalysis of Idealized Plutonium Dissolvers and the 'Always Safe'Conditions," ARH-LD-109, Atlantic Richfield Hanford Company, February, 1975.